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Title of Invention: TRANSPARENT TOUCH PANEL AND LIQUID CRYSTAL DISPLAY DEVICE OF TOUCH INPUT TYPE USING THE TRANSPARENT TOUCH PANEL

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[Document Name] Specification

[Title of the Invention]

TRANSPARENT TOUCH PANEL AND LIQUID CRYSTAL DISPLAY DEVICE OF TOUCH INPUT TYPE USING THE TRANSPARENT TOUCH PANEL

[What is claimed is]

[Claim 1] A transparent touch panel equipped with an antireflection function, comprising: a movable electrode portion disposed on a lower surface of an upper optical phase difference film which gives a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region; and an upper polarizer laminated on an upper surface of the upper optical phase difference film and having a polarization axis angled about 45° or about 135° to an optical axis of the upper optical phase difference film, characterized in that a transparent film is laminated on the upper surface of the upper polarizer.

[Claim 2] A transparent touch panel according to Claim 1, wherein an upper surface of the transparent film laminated on the upper surface of the upper polarizer is treated for low reflection.

[Claim 3] A transparent touch panel according to Claim 1, wherein an upper surface of the transparent film laminated on the upper surface of the upper polarizer is treated for antifouling.

[Claim 4] A transparent touch panel according to Claim 1, wherein an upper surface of the transparent film laminated on the upper surface of the upper polarizer is treated for

hard coating.

[Claim 5] A touch-input type liquid crystal display device comprising: an upper polarizer laminated on an upper surface of a transparent touch panel in which an upper optical phase difference film and a lower optical phase difference film are disposed with a space layer interposed therebetween, the upper optical phase difference film serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region and having a movable electrode portion on a lower surface thereof, and the lower optical phase difference film serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region and having a stationary electrode portion on an upper surface thereof; a liquid crystal display provided on a lower side of the transparent touch panel; and a lower polarizer disposed on a lower surface of the liquid crystal display, wherein an angle formed by an optical axis of the upper optical phase difference film and a polarization axis of the upper polarizer is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film and a polarization axis of light emitted from the liquid crystal display is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film and the optical axis of the lower optical phase difference film is about 90°, characterized in that a transparent film is laminated on the upper surface of the upper polarizer.

[Claim 6] A touch-input type liquid crystal display device comprising: an upper polarizer laminated on an upper surface of a transparent touch panel in which an upper optical phase difference film and a glass substrate are disposed with a space layer interposed therebetween, the upper optical phase difference film serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region and having a movable electrode portion on a lower surface thereof, and the glass substrate having a stationary electrode portion on an upper surface thereof; a liquid crystal display provided on a lower side of the transparent touch panel; a lower optical phase difference film disposed between the transparent touch panel and the liquid crystal display and serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region; a lower optical phase difference film disposed on a lower surface of the liquid crystal display; and a lower polarizer disposed on a lower surface of the liquid crystal display, wherein an angle formed by an optical axis of the upper optical phase difference film and a polarization axis of the upper polarizer is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film and a polarization axis of light emitted from the liquid crystal display is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film and the optical axis of the lower optical phase difference

film is about 90°, characterized in that a transparent film is laminated on the upper surface of the upper polarizer.

[Claim 7] A touch-input type liquid crystal display device comprising: an upper polarizer laminated on an upper surface of a transparent touch panel in which an upper optical phase difference film and an optically isotropic film are disposed with a space layer interposed therebetween, the upper optical phase difference film serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region and having a movable electrode portion on a lower surface thereof, and the optically isotropic film having a stationary electrode portion on an upper surface thereof; a liquid crystal display provided on a lower side of the transparent touch panel; a lower optical phase difference film disposed between the transparent touch panel and the liquid crystal display and serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region; a lower optical phase difference film disposed on a lower surface of the liquid crystal display; and a lower polarizer disposed on a lower surface of the liquid crystal display, wherein an angle formed by an optical axis of the upper optical phase difference film and a polarization axis of the upper polarizer is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film and a polarization axis of light emitted from the liquid crystal display is about 45° or about 135°, and an angle formed by

the optical axis of the upper optical phase difference film and the optical axis of the lower optical phase difference film is about 90°, characterized in that a transparent film is laminated on the upper surface of the upper polarizer.

[Claim 8] A touch-input type liquid crystal display device according to any one of Claims 5 to 7, wherein an upper surface of the transparent film laminated on the upper surface of the upper polarizer is treated for low reflection.

[Claim 9] A touch-input type liquid crystal display device according to any one of Claims 5 to 7, wherein an upper surface of the transparent film laminated on the upper surface of the upper polarizer is treated for antifouling.

[Claim 10] A touch-input type liquid crystal display device according to any one of Claims 5 to 7, wherein an upper surface of the transparent film laminated on the upper surface of the upper polarizer is treated for hard coating.

[Detailed Explanation of the Invention]

[0001]

[Technical Field to which the Invention pertains]

The present invention relates to a transparent touch panel, as well as a liquid crystal display device of a touch input type using this transparent touch panel, which is high in contrast and high in visibility by virtue of its capability of suppressing reflected light of fluorescent lamps or the like indoors, and reflected light due to external light outdoors, and moreover which is superior in surface durability and prevented from moisture absorption

into the upper polarizer.

[0002]

[Conventional Art]

Conventionally, there has been provided a touch-input type liquid crystal display device in which a liquid crystal display 2 is provided under a transparent touch panel 1, the transparent touch panel 1 having a movable-side sheet 20 and a stationary-side sheet 21 disposed with a space layer 7 interposed therebetween, and in which an upper polarizer 8 and a lower polarizer 9 are disposed on the upper and lower surfaces of the liquid crystal display 2 (see Fig. 7).

[0003]

There has also been provided a liquid crystal display device in which the upper polarizer 8 is not provided on the upper surface of the liquid crystal display 2 but provided on the upper surface of the movable-side sheet 20 of the transparent touch panel 1 so as to increase its contrast.

[0004]

However, with such a touch-input type liquid crystal display device having the above constitution, in such places as a room with a fluorescent lamp or an outdoor place, the display screen would be quite hard to view because of the reflection of light at two places, one being an interface between a space layer of the transparent touch panel 1 and a stationary electrode portion set on the upper

surface of the stationary-side sheet and the other being the uppermost surface of the transparent touch panel 1. The reason of this is that at the passage of light from one medium of lower refractive index to another of higher refractive index, the larger the difference between those refractive indices is, the more the reflection of light occurs at the interface.

[0005]

In the case of the constitution in which the upper polarizer 8 is disposed on the upper surface of the movable-side sheet 20 of the transparent touch panel 1, indeed a method of preventing reflected light by forming the upper surface of the upper polarizer 8 into a translucent state is also available, but reflected light cannot be suppressed enough.

[0006]

Under these circumstances, it was devised to solve the above-described issues by providing touch-input type liquid crystal display devices as shown in the following (1) to (3).

[0007]

(1) A touch-input type liquid crystal display device comprising: an upper polarizer 8 laminated on an upper surface of a transparent touch panel 1 in which an upper optical phase difference film 4 and a lower optical phase difference film 6 are disposed with a space layer 7 interposed therebetween, the upper optical phase difference film 4 serving to give a phase delay of a 1/4 wavelength to

incident light of center wavelength within a visible region and having a movable electrode portion 3 on a lower surface thereof, and the lower optical phase difference film 6 serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region and having a stationary electrode portion 5 on an upper surface thereof; a liquid crystal display 2 provided on a lower side of the transparent touch panel 1; and a lower polarizer 9 disposed on a lower surface of the liquid crystal display 2, wherein an angle formed by an optical axis of the upper optical phase difference film 4 and a polarization axis of the upper polarizer 8 is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film 6 and a polarization axis of light emitted from the liquid crystal display 2 is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film 4 and the optical axis of the lower optical phase difference film 6 is about 90° (see Fig. 8).

[0008]

(2) A touch-input type liquid crystal display device comprising: an upper polarizer 8 laminated on an upper surface of a transparent touch panel 1 in which an upper optical phase difference film 4 and a glass substrate 11 are disposed with a space layer 7 interposed therebetween, the upper optical phase difference film 4 serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region and having a movable

electrode portion 3 on a lower surface thereof, and the glass substrate 11 having a stationary electrode portion 5 on an upper surface thereof; a liquid crystal display 2 provided on a lower side of the transparent touch panel 1; a lower optical phase difference film 6 disposed between the transparent touch panel 1 and the liquid crystal display 2 and serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region; and a lower polarizer 9 disposed on a lower surface of the liquid crystal display 2, wherein an angle formed by an optical axis of the upper optical phase difference film 4 and a polarization axis of the upper polarizer 8 is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film 6 and a polarization axis of light emitted from the liquid crystal display 2 is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film 4 and the optical axis of the lower optical phase difference film 6 is about 90° (see Fig. 9).

[0009]

(3) A touch-input type liquid crystal display device comprising: an upper polarizer 8 disposed on an upper surface of a transparent touch panel 1 in which an upper optical phase difference film 4 and an optically isotropic film 12 are disposed with a space layer 7 interposed therebetween, the upper optical phase difference film 4 serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region

and having a movable electrode portion 3 on a lower surface thereof, and the optically isotropic film 12 having a stationary electrode portion 5 on an upper surface thereof; a liquid crystal display 2 provided on a lower side of the transparent touch panel 1; a lower optical phase difference film 6 disposed between the transparent touch panel 1 and the liquid crystal display 2 and serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region; and a lower polarizer 9 disposed on a lower surface of the liquid crystal display 2, wherein an angle formed by an optical axis of the upper optical phase difference film 4 and a polarization axis of the upper polarizer 8 is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film 6 and a polarization axis of light emitted from the liquid crystal display 2 is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film 4 and the optical axis of the lower optical phase difference film 6 is about 90° (see Fig. 10).

[0010]

That is, by the arrangement that the angle formed by the polarization axis of the upper polarizer and the optical axis of the upper optical phase difference film is about 45°C or about 135°C, incident light passes through the transparent touch panel in the form of circularly polarized light or elliptically polarized light, and then reflected circularly polarized light or elliptically polarized light

passes through the upper optical phase difference film again, resulting in linearly polarized light vertical to the polarization axis of the upper polarizer. Thus, suppression of reflected light was achieved.

[0011]

Also, by the arrangement that the optical axis of the lower optical phase difference film is disposed between the transparent touch panel and the liquid crystal display so as to be angled about 90° to the optical axis of the upper optical phase difference film and to be angled about 45° to the polarization axis of the lower polarizer, coloring of the display screen as viewed from the observer side can be suppressed. Thus, a coloring-free, high-contrast display screen was obtained.

[0012]

[Subject to be solved by the Invention]

However, in the touch-input type liquid crystal display devices of (1) to (3) as described above, although the upper polarizer is laminated on the upper surface of the upper optical phase difference film of the transparent touch panel, the surface of the upper polarizer is of poor durability so that the surface of the upper polarizer is damaged by pen input or the like. Thus, the touch-input type liquid crystal display devices are of poor practicability.

[0013]

Also, since moisture is absorbed from the surface

of the upper polarizer, the upper polarizer becomes more prone to contraction and expansion or distortion, so that the upper optical phase difference film bonded to the upper polarizer is resultantly changed partly in retardation value, in which case irregular colors become noticeable from the observer side and besides the antireflection function might be impaired.

[0014]

Accordingly, an object of the present invention is to provide a transparent touch panel which is superior in surface durability and prevented from moisture absorption to the upper polarizer, as well as a touch-input type liquid crystal display device using the transparent touch panel, by solving the above-described issues.

[0015]

[Means for solving the Subject]

In order to achieve the above object, a touch-input type liquid crystal display device according the present invention is constructed by comprising: an upper polarizer laminated on an upper surface of a transparent touch panel in which an upper optical phase difference film and a lower optical phase difference film are disposed with a space layer interposed therebetween, the upper optical phase difference film serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region and having a movable electrode portion on a lower surface thereof, and the lower optical phase

difference film serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region and having a stationary electrode portion on an upper surface thereof; a liquid crystal display provided on a lower side of the transparent touch panel; and a lower polarizer disposed on a lower surface of the liquid crystal display, wherein an angle formed by an optical axis of the upper optical phase difference film and a polarization axis of the upper polarizer is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film and a polarization axis of light emitted from the liquid crystal display is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film and the optical axis of the lower optical phase difference film is about 90°, constructed in that a transparent film is laminated on the upper surface of the upper polarizer (first invention).

[0016]

A touch-input type liquid crystal display device according to the present invention is constructed by comprising: an upper polarizer laminated on an upper surface of a transparent touch panel in which an upper optical phase difference film and a glass substrate are disposed with a space layer interposed therebetween, the upper optical phase difference film serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region and having a movable electrode portion on a

lower surface thereof, and the glass substrate having a stationary electrode portion on an upper surface thereof; a liquid crystal display provided on a lower side of the transparent touch panel; a lower optical phase difference film disposed between the transparent touch panel and the liquid crystal display and serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region; a lower optical phase difference film disposed on a lower surface of the liquid crystal display; and a lower polarizer disposed on a lower surface of the liquid crystal display, wherein an angle formed by an optical axis of the upper optical phase difference film and a polarization axis of the upper polarizer is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film and a polarization axis of light emitted from the liquid crystal display is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film and the optical axis of the lower optical phase difference film is about 90°, constructed in that a transparent film is laminated on the upper surface of the upper polarizer (second invention).

[0017]

A touch-input type liquid crystal display device according to the present invention is constructed by comprising: an upper polarizer laminated on an upper surface of a transparent touch panel in which an upper optical phase

difference film and an optically isotropic film are disposed with a space layer interposed therebetween, the upper optical phase difference film serving to give a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region and having a movable electrode portion on a lower surface thereof, and the optically isotropic film having a stationary electrode portion on an upper surface thereof; a liquid crystal display provided on a lower side of the transparent touch panel; a lower optical phase difference film disposed between the transparent touch panel and the liquid crystal display and serving to give a phase delay of a 1/4 wavelength to the incident light of the center wavelength within the visible region; a lower optical phase difference film disposed on a lower surface of the liquid crystal display; and a lower polarizer disposed on a lower surface of the liquid crystal display, wherein an angle formed by an optical axis of the upper optical phase difference film and a polarization axis of the upper polarizer is about 45° or about 135°, an angle formed by an optical axis of the lower optical phase difference film and a polarization axis of light emitted from the liquid crystal display is about 45° or about 135°, and an angle formed by the optical axis of the upper optical phase difference film and the optical axis of the lower optical phase difference film is about 90°, constructed in that a transparent film is laminated on the upper surface of the upper polarizer (third invention).

[0018]

Accordingly, in these first to third inventions, a transparent touch panel equipped with an antireflection function, is constructed by comprising: a movable electrode portion disposed on a lower surface of an upper optical phase difference film which gives a phase delay of a 1/4 wavelength to incident light of center wavelength within a visible region; and an upper polarizer laminated on an upper surface of the upper optical phase difference film and having a polarization axis angled about 45° or about 135° to an optical axis of the upper optical phase difference film, characterized in that a transparent film is laminated on the upper surface of the upper polarizer.

[0019]

In each of the above constructions, an upper surface of the transparent film laminated on the upper surface of the upper polarizer may be treated for low reflection.

[0020]

In each of the above constructions, an upper surface of the transparent film laminated on the upper surface of the upper polarizer may be treated for antifouling.

[0021]

In each of the above constructions, an upper surface of the transparent film laminated on the upper surface of the upper polarizer may be treated for hard

coating.

[0022]

[Embodiments of the Invention]

Hereinbelow, the present invention is described in detail with reference to the accompanying drawings. Fig. 1 is a sectional view showing an embodiment of the touch-input type liquid crystal display device (transmission type TN) according to the first invention. Fig. 2 is a sectional view showing an embodiment of the touch-input type liquid crystal display device (transmission type STN) according to the second invention. Fig. 3 is a sectional view showing an embodiment of the touch-input type liquid crystal display device (reflection type STN) according to the third invention. Fig. 4 is an explanatory view of the direction of polarization axis and the direction of optical axis in a touch-input type liquid crystal display device (TN) according to the present invention. Fig. 5 is a sectional view showing another embodiment of the touch-input type liquid crystal display device (transmission type TN) according to the first invention. Fig. 6 is a sectional view showing another embodiment of the touch-input type liquid crystal display device (reflection type STN) according to the third invention.

[0023]

In the figures, reference numeral 1 denotes a transparent touch panel, 2 denotes a liquid crystal display, 3 denotes a movable electrode portion, 4 denotes an upper optical phase difference film, 5 denotes a stationary

electrode portion, 6 denotes a lower optical phase difference film, 7 denotes a space layer, 8 denotes an upper polarizer, 9 denotes a lower polarizer, 10 denotes spacers, 11 denotes a glass substrate, 12 denotes an optically isotropic film, 13 denotes a backlight guide plate, 14 denotes an optical-compensation phase difference plate, 15 denotes a reflecting plate, 16 denotes a transparent resin plate, 22 denotes a transparent film, 23 denotes a low reflection process, 24 denotes an antifouling process and 25 denotes a hard coating process.

[0024]

The movable electrode portion 3 comprises a transparent electrically conductive film, leads and the like. The material of the movable electrode portion 3 is exemplified by metallic oxides such as tin oxide, indium oxide, antimony oxide, zinc oxide, cadmium oxide, or indium tin oxide (ITO), composite films composed primarily of these metallic oxides, gold, silver, copper, tin, nickel, aluminum, palladium or the like.

[0025]

The upper optical phase difference film 4 is a film or plate which has a function of changing linearly polarized light into circularly polarized light or elliptically polarized light by giving a time-base phase shift to two components of polarized light perpendicular to each other resulting from decomposing the linearly polarized light, and a function of delaying the phase of one component of the polarized light by a 1/4 wavelength

with respect to incident light of center wavelength of the visible region. That is, by using this upper optical phase difference film 4, one of the two components of polarized light perpendicular to each other resulting from decomposing the linearly polarized light is given a phase delay of a 1/4 wavelength of the about 550 nm center wavelength of the visible region, i.e. an about 138 nm phase delay. In this case, if the two components of polarized light perpendicular to each other are equal in amplitude to each other, circularly polarized light results, and otherwise elliptically polarized light results.

[0026]

Because the upper optical phase difference film 4 is high-temperature treated during the formation of the movable electrode portion 3 and the circuit formation, the film used is required to have thermal resistance. In the case of films having lower thermal deformation temperatures, the retardation value, which is a value of phase delay between the two components of polarized light, would be changed, in which case the visibility of the display screen would be inferior with the constitution of the touch-input type liquid crystal display device according to the present invention. However, it has been found that the higher the thermal deformation temperature of the film is, the smaller the change of the retardation value becomes. Such a material is exemplified by uniaxial oriented polymeric films having a thermal deformation temperature of 130°C or more, e.g., polycarbonate, polyarylate, polyethersulfone,

polysulfone, or the like. Particularly, uniaxial oriented polyarylate, polyethersulfone, or polysulfone films having a thermal deformation temperature of 170°C or more are preferable as the film material. The film thickness of the upper optical phase difference film 4 is preferably not less than 50 μm and not more than 150 μm. If the thickness of the upper optical phase difference film 4 is over 150 μm, the total thickness in combination with the upper polarizer 8 would be so large that input by finger or pen would feel heavy with smart input of characters disabled. Besides, if the thickness is less than 50 μm, the film itself would be poor in flexibility and yield film wrinkles or corrugations during the circuit formation, so that lamination with the upper polarizer 8 would be difficult. The thickness is more preferably not less than 75 μm and not more than 125 μm.

[0027]

As the base material for forming the stationary electrode portion 5, the lower optical phase difference film 6 (first invention; see Fig. 1) or the glass substrate 11 (second invention; see Fig. 2) or the optically isotropic film 12 (third invention; see Fig. 3) is used. These base materials are also high temperature treated during the formation of the stationary electrode portion 5 and the circuit formation, as in the upper optical phase difference film 4.

[0028]

Therefore, the material of the lower optical phase difference film 6 may be the same as that of the upper

optical phase difference film 4, and is preferably given by uniaxial oriented films of polyarylate, polyethersulfone, polysulfone or the like having a thermal deformation temperature of 170°C or more. The material of the optically isotropic film 12 is exemplified by undrawn polymeric films having a thermal deformation temperature of 130°C or more, for example, polycarbonate, polyarylate, polyethersulfone, polysulfone, and the like. In particular, undrawn films of polyarylate, polyethersulfone, polysulfone or the like having a thermal deformation temperature of 170°C or more are preferable.

[0029]

With the use of the lower optical phase difference film 6 and the optically isotropic film 12, the total thickness of the transparent touch panel 1 becomes thinner, making it possible to provide a thinner, more lightweight touch-input type liquid crystal display device. Also, with the use of the glass substrate 11, pressing stability and durability of the finger or pen becomes more stable. Also, if pressing stability and durability equivalent to those of the glass substrate 11 are preferred to the thinness in the first invention, the transparent resin plate 16 may appropriately be disposed between the transparent touch panel 1 and the liquid crystal display 2 (see Fig. 5). If pressing stability and durability equivalent to those of the glass substrate 11 are preferred to the thinness in the third invention, the transparent resin plate 16 may appropriately be disposed between the transparent touch

panel 1 and the lower optical phase difference film 6 (see Fig. 6). As the material of the transparent resin plate 16, resins superior in transparency such as polycarbonate, polyamide, polyether ketone and other engineering plastics, as well as acrylic resins, polyethylene terephthalate resins, polybutylene terephthalate resins, polystyrene resins, cellulose resins and the like are used. The thickness of the transparent resin plate 16 is, for example, 0.3 - 5.0 mm.

[0030]

The movable electrode portion 3 and the stationary electrode portion 5 opposed to each other are spaced from each other with spacers 10. Thus, input is effected by pressing from on the upper optical phase difference film 4 with a finger or pen and thereby causing the movable electrode portion 3 to come into contact with the stationary electrode portion 5.

[0031]

Whereas the upper polarizer 8 is laminated on the upper surface of the upper optical phase difference film 4, the polarization axis of the upper polarizer 8 is set with an inclination of about 45° or about 135° with respect to the optical axis of the upper optical phase difference film 4. The angle of about 45° or about 135° is intended to convert linearly polarized light into circularly polarized light or elliptically polarized light, where an allowance of up to ±3° is permitted. With such an inclination, the two components of polarized light perpendicular to each other

become equal in amplitude to each other, so that the linearly polarized light having passed through the upper optical phase difference film 4 is formed into circularly polarized light or elliptically polarized light.

[0032]

A transparent film 22 is laminated on the upper surface of the upper polarizer 8. As the material for the transparent film 22, resins superior in transparency such as polycarbonate, polyamide, polyether ketone and other engineering plastics, as well as acrylic resins, polyethylene terephthalate resins, polybutylene terephthalate resins, polystyrene resins, cellulose resins and the like are used. The thickness of the transparent film 22 is not more than 100 μm, preferably 80 μm.

[0033]

Also, a low reflection process 23 may be applied to the upper surface of the transparent film 22 laminated on the upper surface of the upper polarizer 8. The low reflection process may be done by applying a low-reflection material using a low-refractive-index resin such as fluororesin or silicon resin, depositing a metallic multilayer film by vapor deposition, laminating a low-reflection film, processing the surface into a translucent state by sand blasting, embossing, mat coating, etching or other processes, and the like. Also, these low reflection processes may be performed in combination.

[0034]

Also, an antifouling process 24 may be applied to

the upper surface of the transparent film 22 laminated on the upper surface of the upper polarizer 8.

[0035]

Also, in order to protect the transparent film 22 laminated on the upper surface of the upper polarizer 8 from wearing due to press by finger or pen, a hard coating process 25 may be applied. For example, a hard coat processed layer made from acrylic resin, silicon resin, UV curing resin or the like is formed.

[0036]

By arranging the transparent touch panel 1 and the upper polarizer 8 in such a constitution as shown above, reflected light due to the light incident from external can be suppressed in the following manner.

[0037]

Incident light that has been transmitted by the transparent film 22 from the observer side passes through the upper polarizer 8, becoming linearly polarized light. When this linearly polarized light passes through the upper optical phase difference film 4 that gives a 1/4 wavelength phase delay to the center-wavelength incident light whose optical axis is inclined by about 45° or about 135° to the polarization axis of the upper polarizer 8, the linearly polarized light is divided into two polarized components perpendicular to each other and equal in amplitude to each other, one polarized component being given a 1/4 wavelength phase delay. As a result, the linearly polarized light is changed into circularly polarized light. As an example, the

light reflected by an interface between the space layer 7 and the stationary electrode portion 5, which is the largest refractive index portion of the interface, passes again through the upper optical phase difference film 4. The light having passed through the upper optical phase difference film 4 is changed from circularly polarized light into linearly polarized light, where the polarization axis of the linearly polarized light changes about 90°, resulting in linearly polarized light nearly vertical to the polarization axis of the upper polarizer 8, so that light no longer passes through. Thus, reflected light is suppressed.

[0038]

Also, in order to suppress coloring of the display screen of the liquid crystal display device as viewed from the observer side, a lower optical phase difference film 6 that gives a 1/4 wavelength phase delay to the center-wavelength incident light is disposed between the upper optical phase difference film 4 and the liquid crystal display 2 of the transparent touch panel 1. More preferably, when the lower optical phase difference film 6 is laminated on the upper surface of the liquid crystal display 2 by the medium of a transparent adhesive or the like, not only the coloring of the display screen can be suppressed but also reflected light can be suppressed more effectively.

[0039]

In this case, the lower optical phase difference film 6 is so positioned that the optical axis of the upper

optical phase difference film 4 and the optical axis of the lower optical phase difference film 6 forms an angle of about 90°. The angle of about 90° is intended to change the circularly polarized light or elliptically polarized light into linearly polarized light, where an allowance of ±3° is permitted.

[0040]

Further, the lower optical phase difference film 6 is so positioned that the optical axis of the lower optical phase difference film 6 is angled about 45° or about 135° with respect to the polarization axis of the linearly polarized light emitted from the liquid crystal display 2. The angle of about 45° or about 135° is intended to change the linearly polarized light into circularly polarized light or elliptically polarized light, where an allowance of ±3° is permitted. In addition, in the case of the lower optical phase difference film 6 in which the stationary electrode portion 5 is provided on its upper surface, coloring of the display screen can be suppressed and, because the lower optical phase difference film 6 also forms part of the transparent touch panel 1, there is no need of providing the optical phase difference film.

[0041]

As the liquid crystal display system to be used for the liquid crystal display 2, available are transmission- and reflection-type TN liquid crystal display systems, transmission- and reflection-type STN display systems, and the like. In any case of these liquid crystal

display systems, the lower optical phase difference film 6 may appropriately be positioned so that the optical axis of the lower optical phase difference film 6 forms an angle of about 45° or about 135° with respect to the polarization axis of the linearly polarized light emitted from the liquid crystal display 2.

[0042]

In the cases of the transmission- and reflection-type STN liquid crystal display systems, as the constitution of the liquid crystal display 2, an optical-compensation phase difference plate 14 for preventing the coloring of the display screen and enhancing the contrast is generally provided on top of a liquid crystal cell in addition to the liquid crystal cell.

[0043]

In the case of general TN liquid crystal display, light outputted from the backlight guide plate 13, passing through the polarizer 9, results in linearly polarized light as shown in Fig. 4. This linearly polarized light, when passing through the liquid crystal display 2, results in linearly polarized light twisted 90°. Further, light that has passed through the lower optical phase difference film 6 becomes circularly polarized light and then returned again to linearly polarized light by the upper optical phase difference film 4. At this time point, because the angle between the optical axes of the two optical phase difference films is about 90°, the polarization axis of the resulting linearly polarized light is coincident with the polarization

axis of the upper polarizer 8. That is, the linearly polarized light is coincident with the transmission axis. Therefore, this linearly polarized light is allowed to pass through the polarizer 8 so that light can reach the observer.

[0044]

Also, in the touch-input type liquid crystal display device having a constitution as described above, the transparent touch panel 1 and the liquid crystal display 2, or these members and all members between these members indeed may be bonded by double-sided adhesive tape at places outside the display screen area, but more preferably, bonded overall by a transparent adhesive layer or a transparent re-peel sheet. In addition, all the members may be bonded to one another only by either one of transparent adhesive layer and transparent re-peel sheet, and it is also possible that some members are bonded by a transparent adhesive layer while other members are bonded by a transparent re-peel sheet.

[0045]

The transparent adhesive layer is a coating of a general transparent adhesive. This adhesive is exemplified by acrylic resins such as acrylic ester copolymers, urethane resins, silicon resins, or rubber base resins. The transparent re-peel sheet is a gel sheet formed from a transparent polymeric adhesive. The polymeric adhesive is exemplified by urethane, acrylic, natural polymeric materials, or the like. By the transparent adhesive layer or the transparent re-peel sheet, the air space between the

transparent touch panel 1 and the liquid crystal display 2 can be eliminated. Still more, because the refractive index of these transparent adhesive layer and the transparent re-peel sheet is larger than air, close to the refractive indices of such members as the lower optical phase difference film 6, the glass substrate 11, the lower optically isotropic film 12, the transparent resin plate 16, the glass plate forming the liquid crystal display 2, and the like, the reflection of light at the interfaces between the transparent adhesive layer or the transparent re-peel sheet and these members is suppressed, so that the transmittance finally becomes higher than that of a constitution having an air space in the case where double-sided tape is used. Besides, because the refractive index of the transparent adhesive layer or the transparent re-peel sheet is close to the refractive indices of the above-mentioned members, refraction of light at the interface between the transparent adhesive layer or the transparent re-peel sheet and the members is suppressed, so that no shadows are formed in the screen display.

[0046]

Also, the members bonded to each other by the transparent re-peel sheet are characterized by being highly resistant to a vertically-acting pull-away force and a horizontally-displacing force, and easily being separated away from each other when pulled away from both sides in such a manner that the members are peeled off from their ends. Accordingly, there is no afraid of peels in normal

use state of the members after the mounting, so that the members can easily be peeled off for maintenance or other occasions. In addition, it is needless to say that the adhesive power of the transparent re-peel sheet does not lower even by repeated removals. Also, in the case where an urethane base polymeric adhesive is used, because the transparent re-peel sheet is a material having both water absorbing and gas sucking properties, the transparent re-peel sheet, when fitted, absorbs the air bubbles mixed between the members at room temperature, so that a product free from air bubbles can finally be obtained without any special treatment. In addition, the terms, any special treatment, refer to such treatment as expelling air bubbles by moving a roll while a pressure is applied from an end portion of the surface of the transparent touch panel 1. Such a special treatment cannot be applied in the case of a transparent touch panel 1 using the glass substrate 11, in which case the aforementioned air bubble absorbing effect at room temperature is quite useful.

[0047]

[Effects of the Invention]

Since the present invention has the above constitutions and functions, there can be obtained a touch-input type liquid crystal display device which is high in contrast and high in visibility by suppressing reflected light of fluorescent lamps or the like indoors, and reflected light due to external light outdoors by means of the upper polarizer and individual layers behind the upper

polarizer. Moreover, the invention produces the following effects by means of the transparent film laminated on the upper surface of the upper polarizer.

[0048]

That is, by the lamination of the transparent film onto the upper surface of the upper polarizer, the surface durability becomes better so that the surface of the upper polarizer can be prevented from being damaged even with pen input or finger input or the like.

[0049]

Also, by the lamination of the transparent film onto the upper surface of the upper polarizer, moisture absorption from the surface of the upper polarizer can be prevented, so that contraction and expansion as well as distortion of the upper polarizer due to the moisture absorption can be suppressed. Therefore, variations of the retardation value of the upper optical phase difference film laminated on the upper polarizer can be suppressed, irregular colors do not occur, and moreover the antireflection function is never impaired.

[Brief Description of the Drawings]

Fig. 1 is a sectional view showing an embodiment of the touch-input type liquid crystal display device (transmission type TN) according to the first invention.

Fig. 2 is a sectional view showing an embodiment of the touch-input type liquid crystal display device (transmission type STN) according to the second invention.

Fig. 3 is a sectional view showing an embodiment

of the touch-input type liquid crystal display device (reflection type STN) according to the third invention.

Fig. 4 is an explanatory view of the direction of polarization axis and the direction of optical axis in a touch-input type liquid crystal display device (TN) according to the present invention.

Fig. 5 is a sectional view showing another embodiment of the touch-input type liquid crystal display device (transmission type TN) according to the first invention.

Fig. 6 is a sectional view showing another embodiment of the touch-input type liquid crystal display device (transmission type TN) according to the third invention.

Fig. 7 is a sectional view showing an embodiment of a liquid crystal display equipped with a conventionally general transparent touch panel.

Fig. 8 is a sectional view showing an embodiment of a liquid crystal display equipped with a transparent touch panel which has been processed for antireflection measures.

Fig. 9 is a sectional view showing an embodiment of a liquid crystal display equipped with a transparent touch panel which has been processed for antireflection measures.

Fig. 10 is a sectional view showing an embodiment of a liquid crystal display equipped with a transparent touch panel which has been processed for antireflection

measures.

[Explanation of Reference Numerals]

1: transparent touch panel

2: liquid crystal display

3: movable electrode portion

4: upper optical phase difference film

5: stationary electrode portion

6: lower optical phase difference film

7: space layer

8: upper polarizer

9: lower polarizer

10: spacers

11: glass substrate

12: optically isotropic film

13: backlight guide plate

14: optical-compensation phase difference plate

15: reflecting plate

16: transparent resin plate

20: movable-side sheet

21: stationary-side sheet

22: transparent film

23: low reflection process

24: antifouling process

25: hard coating process